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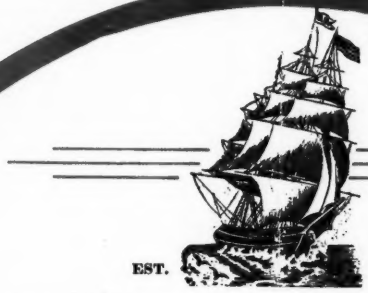

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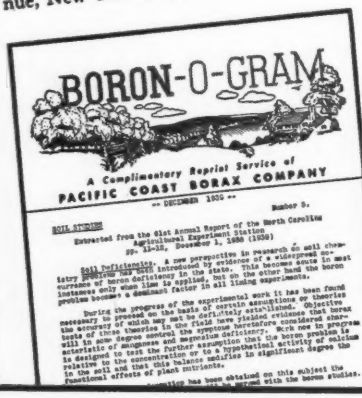
BORON-O-GRAM

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-- DECEMBER 1935 --

Number 9.

SOIL TESTING

Extracted from the 61st Annual Report of the North Carolina Agricultural Experiment Station
(Pp. 15-16, December 3, 1934 (1935))

Soil Deficiencies. A new perspective in research on soil chemistry possibly has been introduced by evidence of a widespread occurrence of boron deficiency in the state. This becomes acute in most instances only when lime is applied, but on the other hand the boron problem becomes a dominant factor in all liming experiments.

During the progress of the experimental work it has been found necessary to proceed on the basis of certain assumptions or theories the accuracy of which may not be definitely established. Objective tests of these theories in the field have therefore considered progress will in some degree control the symptom deficiency. Work now in progress is designed to test the further assumption that the boron problem is relative to the concentration or to a hypothetical activity of calcium in the soil and that this balance modifies in significant degree the functional effects of plant nutrients.

Some data has been obtained on this subject the

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Vol. 93 OCTOBER 26, 1940 No. 9

Comparison and Value of Check Fertilizer Analyses*

By E. W. MAGRUDER

Chief Chemist, F. S. Royster Guano Company

IN 1922 the author began sending fertilizer samples monthly to various chemists interested in fertilizer work. The work was started with thirty-three chemists and the number increased to sixty by 1927, and from that time to the present the number of collaborators has remained in the sixties. During the eighteen years some chemists have dropped out but others have come in and the number now is sixty-eight.

The collaborating chemists are about equally divided between State laboratories, commercial fertilizer laboratories and laboratories of fertilizer manufacturers and, consequently, all classes of fertilizer chemists are represented.

A well prepared and well mixed sample is sent out the first of each month and a compilation of the results is sent the first of the succeeding month.

It is quite gratifying to find how much interest the chemist takes in the samples. A great majority of the collaborators have continued to analyze the samples from the time they joined in the work up to the present, and I have had numerous suggestions from the collaborators as to the samples to be sent, as to the analyses to be made, and the methods to be employed. All such suggestions are most welcome and are complied with whenever possible. I have frequently collaborated with the Referees of the Association of Official Agricultural Chemists by sending some of their samples to my collaborators and by having them try some of the new methods which the Referees wish tested. When the adoption of a new method is about to take place, I have had the collaborators use that method on several samples so that when adopted they would be acquainted with the handling of the method, and would have no difficulty in putting it into operation and could get accurate results at once. Many have found this very helpful.

Chemists who do not have occasion to check often with other chemists will from time to time get bad results without knowing it and will continue doing so for some time before they find it out, but by analyzing the check samples monthly then can check with other chemists and at once take measures to correct their methods.

I have frequently had occasion to bring to the attention of the chemists the effect different kinds of filter papers have on the results, by having them use different grades of filter paper and by this means have gotten them to follow A. O. A. C. methods which they had overlooked.

It is surprising how many chemists will overlook one or another feature of our official methods. For instance, when a sample is sent out containing cottonseed meal or some other seed meal, many will fail to destroy the organic matter before determining the phosphoric acid and, in consequence, their results will be several tenths of a per cent too low. Many will obtain too low insoluble phosphoric acid results by using a course paper for filtering out the citrate-soluble phosphoric acid in high percentage superphosphates instead of using a fine paper of the grade of a Whatman

* A paper presented at the meeting of the Division of Fertilizer Chemistry, American Chemical Society, Detroit, Mich., September 11, 1940.

No. 5 as recommended by the A. O. A. C. Methods. These points and others have been frequently brought to the attention of the collaborators and there has been a decided improvement, but there are still some who ignore the presence of the meals and the use of the proper filter paper.

In a routine laboratory the work frequently becomes monotonous and I have found that much interest is added by having the results of many other chemists to come in monthly on the same samples you have analyzed, with which to compare your results, and anything which will add interest to the work is well worthwhile.

While the results on the whole are better now than when the check work was started, it is still surprising what large variations often occur on the same sample, which proves that our methods and the way in which the methods are carried out still need much improvement.

The variation in the results in the determination of moisture is surprising for it is rare that there is not more than two per cent variation on the sample by different chemists. We should certainly be able to do better than that. One of the causes of this variation, I think, is due to the calcium sulphate present in superphosphates. As this material has more or less water of crystallization and as this water will come off at different temperatures under different conditions, it is difficult to always secure the same conditions and, therefore, the results will vary. I believe that a careful study should be made of determining the moisture in fertilizers so that we could get more accurate results.

Chemists not infrequently make mistakes in reporting their results. Sometimes I can detect the mistake when it is due to incorrectly subtracting the insoluble phosphoric acid from the total, but if in other cases the figures are put down incorrectly, I have no means of finding it out and the results are printed as received. To the receiver of any analysis, putting down the results incorrectly is as bad as an incorrect analysis. A chemist, after taking the trouble to make a correct analysis, should certainly take the little additional trouble to see that it is reported correctly, and I recommend that all chemists pay particular attention to this point.

As the grade of fertilizers is increasing and as much higher grade materials are being used than formerly, the fineness of the grinding of a sample becomes a question of much importance. The drier a fertilizer sample is, the harder it is to keep well mixed unless finely ground. If moist enough to keep from sifting or segregating, about as good results will be obtained when put through a 20 mesh screen as through a 30 or 35 mesh screen. If, however, it is high grade and dry enough to dust and roll and sift, very poor results will be obtained when put through a 20 mesh screen and it becomes necessary to put the sample through a much finer one—certainly through a 30 mesh and, in many cases, through a 35 mesh screen.

By putting different parts of the sample of fertilizer through different sieves, at times I have obtained very erratic results which I have never been able to explain. In all cases, however, much more concordant results have been obtained by putting the sample through a fine sieve, and I recommend that all high grade fertilizers be put through a 35 mesh screen. Low grade fertilizers can still be put through a 20 mesh screen, and medium grade with enough moisture to prevent sifting can be put through a 20 mesh and, in some cases, through a 30 mesh screen.

Dr. W. H. Ross as Referee of the A. O. A. C. on phosphoric acid is now at work on the question of how fine a sample should be ground and I think at the A. O. A. C. meeting this fall he will have some valuable information to report on this subject. The results we obtained on the samples he sent out certainly show the necessity of fine grinding.

One use which has been made of the results of the check fertilizer analyses was certainly not contemplated when the work was started and is as follows: In several cases when a fertilizer law in some of the states has been up for amendment, the legislators have been inclined to be very strict in requiring the fertilizers to come up to guarantee in every particular and have not been inclined to allow the overage in one ingredient to make up for the deficiency in another, but when the check fertilizer results have been shown to them and they have seen how different chemists vary on identically the same sample, they have become more lenient and have allowed a reasonable variation from the guarantee.

During the eighteen years the check fertilizer samples have been sent out there has been a marked improvement in the accuracy of the results received and there has been no let-up in the interest shown by the collaborators, and I wish to take this opportunity of thanking all who are engaged in the work for the help they have rendered me and for the many suggestions offered and for their generous cooperation.

New and Old Methods of Processing Phosphate*

By K. D. JACOB

Division of Fertilizer Research, Bureau of Plant Industry, Washington, D. C.

(Continued from the October 12 issue)

Ammoniated Superphosphates

Monocalcium phosphate, the principal phosphate component of ordinary and double superphosphates, is an acid salt that readily absorbs free ammonia to form a mixture of ammonium salts and water-insoluble calcium phosphates.[10] The quantity of ammonia that can be added without serious formation of citrate-insoluble phosphate amounts to about 3 per cent with ordinary superphosphate and 9 per cent with double superphosphate.

With the large-scale development of the domestic fixed-nitrogen industry, ammonia, in the form of the anhydrous liquid and of aqueous solutions, became available at a price below that of other forms of nitrogen. This has resulted in the use of a considerable quantity of free ammonia in the manufacture of mixed fertilizer. For example, in 1937 the fertilizer industry consumed for this purpose 6,000 short tons of anhydrous ammonia, 25,000 tons of ammonia liquor (containing 30 per cent of ammonia), and 70,000 tons of ammoniating solutions (containing nitrogen equivalent to 45 to 55 per cent of ammonia).[11]

Aside from the lower cost of the nitrogen, ammoniation greatly improves the mechanical condition and the drilling and storing qualities of superphosphate and mixed fertilizers containing superphosphate; it reduces the rotting of fertilizer bags; and it provides a means for the fixation of significant quantities of ammonia with minimum dilution of the superphosphate, which is of considerable importance for the use of ordinary superphosphate in the preparation of high-analysis fertilizer mixtures. Also, a considerable reduction in the quantity of sulphuric acid used in the manufacture of fertilizer materials may be effected by substitution of the free ammonia for ammonium sulphate as a source of nitrogen in mixed fertilizers.

[10] Keenen, F. G., Ind. Eng. Chem. **22**, 1378-82 (1930); Jacob, K. D., Hill, W. L., Ross, W. H., and Rader, L. F., Jr., *ibid.* **22**, 1385-92 (1930); White, L. M., Hardesty, J. O., and Ross, W. H., *ibid.* **27**, 562-7 (1935); Hardesty, J. O., and Ross, W. H., *ibid.* **29**, 1283-90 (1937).

[11] Mehring, A. L., Year Book Com. Fertilizer **1939**, 32-41; Ross, W. H., and Mehring, A. L., U. S. Dept. Agr. Yearbook **1938**, 522-45.

The power of superphosphate to absorb ammonia is used to advantage in the preservation of the nitrogen of manure, particularly in dairy barns. According to Midgley and Weiser of the Vermont Agricultural Experiment Station,[12] ordinary superphosphate is more effective than double superphosphate for this purpose.

Ammonium Phosphates

Two fertilizer grades of monoammonium phosphate are manufactured in this country, principally, if not entirely, by a plant in New Jersey. One grade contains about 11 per cent of nitrogen and 48 per cent of available P_2O_5, while the other contains about 16 per cent of nitrogen and 20 per cent of available P_2O_5, the latter being largely a mixture of ammonium phosphate and ammonium sulphate. A considerable portion of the production is exported. Also, monoammonium phosphate is produced in British Columbia and shipped largely to California and other west-coast States. The manufacture of monoammonium phosphate involves simply the addition of the proper quantity of ammonia to a solution of phosphoric acid and the drying of the resulting slurry in a rotary kiln.[13]

There is no domestic production of diammonium phosphate for fertilizer use. Prior to the outbreak of the present war, however, a small quantity was imported annually, principally as a component of Nitrophoska, a German-made complete fertilizer. Diammonium phosphate has the disadvantage that it loses ammonia in humid atmospheres.

The total domestic consumption of ammonium phosphates for fertilizer purposes amounted to 65,000 short tons in 1937.[14]

Organic Phosphates

The work of Spencer and Stewart, of the Nevada Agricultural Experiment Station,[15] has focused attention on the possible use of certain organic phosphates as a means for decreasing

[12] Vermont Agr. Expt. Sta., Bull. **419**, 23 pp. (1937).

[13] Ross, W. H., Merz, A. R., and Jacob, K. D., Ind. Eng. Chem. **21**, 286-9 (1929).

[14] Mehring, A. L., Year Book Com. Fertilizer **1939**, 32-41.

[15] Soil Science **38**, 65-79 (1934).

the fixation of phosphorus applied to the soil as fertilizer and for increasing its penetration into the root zone of plants. Conrad[16] and Hilbert and co-workers[17] have shown, however, that the behavior of the glycerophosphates, for example, depends markedly on the type of soil, good penetration being obtained in some soils but not in others. Although the soil reactions of organic phosphates merit thorough investigation, and their study will likely afford valuable aid in the solution of the phosphorus-fixation problem, it is doubtful that the economics of their production will be such as to permit their use in the growing of staple crops.

Dicalcium and Tricalcium Phosphates

Dicalcium phosphate,[18] unlike monocalcium phosphate, cannot be obtained by the direct action of acids on phosphate rock. Consequently the fertilizer grade of this compound is usually made by treating a natural phosphate with sufficient hydrochloric acid to effect complete decomposition of the phosphate into phosphoric acid and calcium chloride. The solution is then neutralized with ground limestone or milk of lime and the precipitated dicalcium phosphate is separated from the calcium chloride by filtration. Although a considerable quantity of dicalcium phosphate is made as a by-product of the manufacture of gelatin from bone, the greater portion of the production from this source is used for non-fertilizer purposes. The bulk of the fertilizer grade of material is produced from phosphate rock with hydrochloric acid obtained as a by-product in the manufacture either of potassium sulphate from potassium chloride or of salt cake (sodium sulphate) from sodium chloride.

At the present time, there is no domestic production of dicalcium phosphate from phosphate rock. Mehring[19] estimates the domestic consumption of fertilizer dicalcium phosphate at 6,000 short tons in 1937. In the same year, imports of this material totaled 4,944 short tons, whereas they amounted to 3,791 and 2,592 tons in 1938 and 1939, respectively, in each year principally from Belgium.

From the standpoint of physical properties, dicalcium phosphate is a very desirable fertilizer material. Also, numerous tests have shown that it is equal to superphosphate as a source of phosphorus for the growth of crops on neutral and acid soils. Results obtained in the Tennessee Valley States are given in Table 4. On the other hand, the work of the Idaho and Montana Agricultural Experiment Stations[20] has demonstrated conclusively that dicalcium phosphate, though better than other citrate-soluble phosphates, such as calcium metaphosphate, calcined phosphate and fused phosphate rock, is notably less effective than the water-soluble phosphates (ordinary and double superphosphates) in promoting the growth of crops on the alkaline soils of the West.

Table 4

Relative Crop Yields Produced by Dicalcium and Tricalcium Phosphates in Comparison with No Phosphate and Ordinary Superphosphate, on Unlimed and Limed Soils

[Data from Ball, C. R., "A Study of the Work of the Land-Grant Colleges in the Tennessee Valley Area in Cooperation with the Tennessee Valley Authority," 76 pp. (1939).]

Treatment	Unlimed			Limed		
	Corn	Wheat	Legume Hay	Corn	Wheat	Legume Hay
No phosphate, N and K only	73.8	46.2	84.3	91.8	54.8	109.8
Ordinary superphosphate with N and K	100.0	100.0	100.0	117.8	116.8	148.1
Dicalcium phosphate with N and K	98.1	106 5	101.8	112.8	122.9	153.4
Tricalcium phosphate with N and K	93.3	100.0	100.3	105.9	100.5	142.2

The common but erroneous belief that tricalcium phosphate is the phosphatic component of phosphate rock and bone has caused much confusion concerning the fertilizing value of this compound. Although tricalcium phosphate as such is not marketed as a fertilizer, it is formed to some extent when superphosphates are treated with free ammonia or other basic materials, and it is, therefore, commonly present in mixed fertilizers. Tests made in the Tennessee Valley States (Table 4) and elsewhere[21] show that tricalcium phosphate is a good source of phosphorus for crops on neutral and acid soils, though it is somewhat less effective than either superphosphate or dicalcium phosphate.

[16] J. Agr. Research **59**, 507-18 (1939).

[17] Soil Science **46**, 409-18 (1938).

[18] Fox, E. J., and Whittaker, C. W., Ind. Eng. Chem. **19**, 349-53 (1927); Rieten, J. v.d., IV Congr. intern. tech. chim. ind. agr. Bruxelles **2**, 388-96 (1935).

[19] Year Book Com. Fertilizer **1939**, 32-41.

[20] Green, J. R., Montana Agr. Expt. Sta., Bull. No. **356**, 31 pp. (1938); Willis, W. P., Jr., and Harrington, F. M., *ibid.* No. **369**, 29 pp. (1939); Toevs, J. I., and Baker, G. O., Idaho Agr. Expt. Sta., Bull. No. **230**, 27 pp. (1939).

[21] Ross, W. H., Jacob, K. D., and Beeson, K. C., J. Assoc. Official Agr. Chem. **15**, 227-66 (1932).

Basic Slag

Basic slag is obtained as a by-product of the manufacture of steel from high-phosphorus ores. It is a very important fertilizer in Europe where the production, exclusive of that in the Union of Soviet Socialist Republics, totaled 5,481,783 metric tons in 1937. The better grades of European slags contain 14 to 20 per cent of total P_2O_5, of which 85 per cent or more is soluble in 2 per cent citric acid solution. In the United States, high-phosphorus iron ores are worked only in the Birmingham, Alabama, district. The slag produced from these ores contain 8 to 12 per cent of total P_2O_5,[22] of which about 70 per cent is soluble in 2 per cent citric acid.[23] Beside its value as a source of phosphorus, basic slag is an excellent material for neutralizing soil acidity, and it supplies magnesium and manganese, as well as calcium. Thus far, attempts to manufacture artificial basic slag directly from phosphate rock have met with little success.

Imports of basic slag totaled only 454 short tons in 1939. The domestic consumption of basic slag in 1937 amounted to 40,800 short tons, including 40,000 tons from domestic sources.[24]

Defluorinated Phosphate

Fluorine is a common constituent of phosphate rocks throughout the world.[25] According to the data in Table 5, the average fluorine content of the different types and sources of domestic rock ranges from about 2.9 to 3.8 per cent, with a range of 0.074 to 0.129 in the average ratio of fluorine to P_2O_5. On the basis of the most recent estimates of reserves, the phosphate rock deposits of the United States contain 415,192,000 long tons of fluorine (Table 6).

In the trade, it has long been the custom to express the quality of phosphate rock in terms of the tricalcium phosphate equivalent of the total phosphorus. Doubtless, this custom is largely responsible for the wide-spread belief that tricalcium phosphate is the actual phosphatic component of phosphate rock. It has been shown, however, (1) that tricalcium phosphate is seldom, if ever, present in phosphate rock; (2) that the phosphate has the complex apatite structure; and (3) that the fluorine is combined principally in the phosphate molecule.[26]

By heating silica-bearing phosphate rock at 1,400° C. or higher temperature in the presence of water vapor, the fluorine can be volatilized and the phosphorus converted into a citrate-soluble condition.[27] The defluorinated phosphate, often called calcined phosphate or fused phosphate rock, has several desirable characteristics. The properly prepared material is highly soluble in neutral ammonium citrate solution. It requires no aging or curing and needs only to be ground to the desired fineness for fertilizer purposes. It is nonhygroscopic, has no deleterious effect on fertilizer bags and machinery, and the ground material (unmixed with other sub-

Table 5

Fluorine in Domestic Phosphate Rock

(Rock containing the equivalent of approximately 50% or more of tricalcium phosphate)

Type or Source of Phosphate	Samples Analyzed	Fluorine Range %	Fluorine Average %	$\frac{F}{P_2O_5}$ Range	$\frac{F}{P_2O_5}$ Average
Florida land pebble	66	2.54-3.95	3.76	0.1022-0.1414	0.1142
Florida hard rock	10	3.17-3.95	3.71	0.1014-0.1116	0.1068
Tennessee brown rock	50	2.32-4.08	3.55	0.1012-0.1169	0.1086
Tennessee blue rock	7	3.27-3.77	3.49	0.1084-0.1172	0.1134
Tennessee white rock	4	2.95-3.85	3.38	0.1038-0.1196	0.1093
Kentucky brown rock	2	2.66-3.14	2.90	0.1123-0.1129	0.1126
South Carolina[1]	9	3.19-3.70	3.44	0.1161-0.1332	0.1285
Arkansas	10	2.64-3.39	3.00	0.0958-0.1150	0.1055
Virginia[2]	2	2.83-2.89	2.86	0.0716-0.0758	0.0737
Western States[3]	64	2.45-6.86	3.47	0.0991-0.2483	0.1095

[1] Land rock and river rock.
[2] Apatite.
[3] Idaho, Montana, Utah and Wyoming.

[22] Bowron, R. L., Mining and Metallurgy **18**, 198-9 (1937).
[23] Jacob, K. D., Rader, L. F., Jr., and Ross, W. H., J. Assoc. Official Agr. Chem. **15**, 146-62 (1932).
[24] Mehring, A. L., Year Book Com. Fertilizer **1939**, 32-41.
[25] Jacob, K. D., Hill, W. L., Marshall, H. L., and Reynolds, D. S., U. S. Dept. Agr., Tech. Bull. No. **364**, 90 pp. (1933).
[26] Hendricks, S. B., Hill, W. L., Jacob, K. D., and Jefferson, M. E., Ind. Eng. Chem. **23**, 1413-18 (1931); McConnell, D., Am. Mineralogist **23**, 1-20 (1938).
[27] Jacob, K. D., Reynolds, D. S., and Marshall, H. L., Am. Inst. Mining Met. Engrs., Tech. Publication No. **695**, 14 pp. (1936); Curtis, H. A., Copson, R. L., Brown, E. H., and Pole, G. R., Ind. Eng. Chem. **29**, 766-70 (1937).

stances) does not cake or harden in storage. On the other hand, it is sufficiently alkaline in reaction to cause some loss of ammonia from ammonium salts in fertilizer mixtures. Although defluorinated phosphate is an excellent source of phosphorus for the growth of plants on neutral and acid soils, it, like other citrate-soluble phosphates, is not as effective as the water-soluble phosphates on alkaline soils.[28]

Because of difficulties in its production, defluorinated phosphate has not yet been made at a cost competitive with that of either ordinary superphosphate or double superphosphate. It is the writer's opinion, however, that production of defluorinated phosphate, or a similar material, offers the best possibility of reducing the cost of chemically processed phosphate fertilizer, and that the difficulties in the large-scale manufacture of this type of material will eventually be overcome. Investigations aimed at the solution of the problem are being conducted by the Bureau of Plant Industry and the Tennessee Valley Authority.

Table 6

Estimated Quantities of Fluorine in the Phosphate Deposits of the United States

Type or Source of Phosphate	Grade[1] %	Average Fluorine Content %	Total Quantity of Phosphate Rock[2] Long Tons	Total Quantity of Fluorine Long Tons
Florida:				
River pebble	55 ±	3.1	50,000,000[3]	1,550,000
Land pebble	55-74 ±	3.1	3,491,580,000[3]	108,239,000
Hard rock	40-65 ±	3.2	1,540,259,000[3]	49,288,000
Tennessee:				
Brown rock	40[4]	2.3	96,918,000[5]	2,229,000
Blue rock	55 +	2.9	83,233,000	2,414,000
White rock	55 +	2.7	15,000,000	405,000
Arkansas	55 +	3.0	20,000,000	600,000
Kentucky brown rock	55 +	3.0	863,000	26,000
South Carolina land rock	55 +	3.5	8,798,000	308,000
Virginia apatite	75 +	2.8	2,000,000[6]	56,000
Western states:				
Idaho	70[7]	3.3	5,736,335,000	189,299,000
Montana	70[7]	3.4	391,323,000	13,305,000
Utah	40-70 +	2.5	1,741,480,000[8]	43,537,000
Wyoming	70[7]	3.4	115,754,000	3,936,000
Total			13,293,543,000	415,192,000

[1] Expressed in terms of tricalcium phosphate.

[2] Except as indicated otherwise, the data are from Mansfield, G. R., Am. Inst. Mining Met. Engrs., Tech. Publication No. **1208**, 10 pp. (1940); Economic Geol. **35**, 405-29 (1940).

[3] Total known, probable and possible tonnages.

[4] Minimum average grade.

[5] Data from Smith, R. W., and Whitlatch, G. I., Tenn. Dept. Conservation, Div. Geol., Bull. No. **48**, 444 pp. (1940): includes 6,271,000 tons of 25-35 per cent minimum average grade material.

[6] Data from Jacob, K. D., Year Book Com. Fertilizer **1938**, 28-43, 55, 59.

[7] Approximate grade.

[8] Data from Williams, J. S., Utah Agr. Expt. Sta., Bull. No. **290**, 44 pp. (1939).

[28] Jacob, K. D., and others, J. Agr. Research **50**, 837-48 (1935); Ross, W. H., and Jacob, K. D., J. Assoc. Official Agr. Chem. **20**, 231-49 (1937); Green, J. R., Montana Agr. Expt. Sta., Bull. No. **356**, 31 pp. (1938); Willis, W. P., Jr., and Harrington, F. M., *ibid.* No. **369**, 29 pp. (1939); Toevs, J. L., and Baker, G. O., Idaho Agr. Expt. Sta., Bull. No. **230**, 27 pp. (1939).

Calcium Metaphosphate

Crude calcium metaphosphate [$Ca(PO_3)_2$] can be prepared simply by heating double superphosphate at high temperature, whereby the monocalcium phosphate is completely dehydrated according to the equation

$$Ca(H_2PO_4)_2.H_2O = Ca(PO_3)_2 + 3H_2O$$

A more direct process, such as the one used by the Tennessee Valley Authority at Wilson Dam, Alabama, involves reacting phosphorus pentoxide vapor with phosphate rock at a temperature of approximately 1,200° C.[29] For use as fertilizer, the glassy product, which is practically insoluble in water but is soluble in neutral ammonium citrate solution, needs only to be crushed and ground.

Inasmuch as calcium metaphosphate contains 60 to 65 per cent of available P_2O_5, as compared with 45 to 50 per cent in double superphosphate, it has an advantage over the latter in respect to bagging, transportation and handling costs per unit of P_2O_5. The metaphosphate seems to be an excellent fertilizer for use on acid and neutral soils but not on alkaline soils.[30]

[29] Curtis, H. A., Copson, R. L., and Abrams, A. J., Chem. & Met. Eng. **44**, 140-2 (1937); Curtis, H. A., Copson, R. L., Abrams, A. J., and Junkins, J. N., *ibid.* **45**, 318-22 (1938).

[30] See footnote 28, references 2 to 5.

(Continued on page 22)

October Crop Report

Crop prospects improved about 1 per cent during September and aggregate crop production now seems likely to be the second largest on record. Estimates of the Crop Reporting Board, based on October 1st conditions, show numerous small increases over those of a month ago. These include increases of about 2 per cent for corn, peanuts, potatoes and tobacco, and increases of about 1 per cent for wheat, oats, barley, tame hay, and total fruits. But soybeans show a decrease of 5 per cent, rice 2 per cent, and sweet potatoes 1 per cent.

Though the acreage of field and vegetable crops harvested is expected to be about 7 per cent less than the average prior to recent droughts, and there has been some shifting of acreages towards the less intensive crops, yields per acre are expected to be higher than in any past year except 1937. Aggregate crop production is expected to be about 5.6 per cent above the pre-drought average. This would still leave the 1940 production substantially below the outstanding record of 1937 but 1.6 per cent above production last year and fractionally above other high years such as 1938, 1931, 1928 and 1920.

	Total Production (in thousands)		
		Indicated	
Crop	Average 1929-38	1939	Oct. 1, 1940[1]
Corn, all, bu	2,299,342	2,619,137	2,352,185
Wheat, all, bu.	754,685	754,971	792,332
Winter, bu.	571,067	563,431	555,839
All spring, bu.	183,619	191,540	236,493
Durum, bu.	29,619	34,360	37,020
Other spring, bu.	154,000	157,180	199,473
Oats, bu.	1,024,852	937,215	1,218,273
Barley, bu.	225,486	276,298	308,021
Rye, bu.	38,095	39,249	37,452
Buckwheat, bu.	7,617	5,739	6,048
Flaxseed, bu.	10,846	20,330	30,629
Rice, bu.	44,254	52,306	51,397
Grain sorghums, bu.	84,148	83,102	126,211
Hay, all time, ton.	69,650	75,726	84,504
Hay, wild, ton.	9,298	8,800	8,927
Hay, clover and timothy,[2] ton	26,030	23,640	28,392
Hay, alfalfa, ton	24,597	27,035	29,973
Beans, dry edible, 100-lb. bag	13,086	13,962	14,977
Peas, dry field, bu.	4,288	3,713	3,292
Soybeans for beans, bu.	27,318	87,409	81,541
Peanuts,[3] lb.	1,035,243	1,179,505	1,539,540
Potatoes, bu.	366,949	364,016	389,091
Sweet potatoes, bu.	72,436	72,679	66,131
Tobacco, lb.	1,360,661	1,848,654	1,268,912
Sugarcane for sugar, ton	4,439	6,197	5,609
Sugar beets, ton	8,937	10,773	11,076
Broomcorn, ton	43	30	42
Hops, lb.	[4]34,310	[4]39,380	40,260
Apples, com'l crop, bu.	121,755	143,085	115,162
Peaches, total crop, bu.	[4]52,723	[4]60,822	52,516
Pears, total crop, bu.	[4]26,333	[4]31,047	32,114
Grapes,[5] ton	2,220	2,526	2,530
Pecans, lb.	63,430	63,639	81,829

[1] For certain crops, figures are not based on current indications, but are carried forward from previous reports.

[2] Excludes sweetclover and lespedeza.

[3] Picked and threshed.

[4] Includes some quantities not harvested.

[5] Production includes all grapes for fresh fruit, juice, wine, and raisins.

The production of feed grains this season appears to be large enough to feed livestock on hand at a nominal rate per head without drawing on reserves. Corn production is now estimated at 2,352 million bushels. This is about 2 per cent above average production during the 1929-38 period, which includes several drought years, but is lower than in 9 of the previous 10 seasons.

Production of the principal food crops in 1940 appears to be quite generally above average. Most are above average in proportion to population. Comparing present estimates with averages for the 1929-1938 period, which includes several drought years and a period when the population was about 4 per cent lower than at present, wheat production, estimated at 792 million bushels, shows an increase of 38 million bushels or 5 per cent above average; and rice production, estimated at 51 million bushels is above the average by 16 per cent. Adding an average crop of rye and a very small crop of buckwheat, the prospective production of the 4 grains is 26 million tons which would be 5 per cent above the average. Beans, estimated at almost 15 million bags are 2 million above average. Soybeans, a source of vegetable oil that has been increasing very rapidly, dropped back this year to 82 million bushels, about 6 million below last year but still about 3 times the 10-year average production. Potatoes will be plentiful; the estimate of 389 million bushels is above average production by 22 million bushels or 6 per cent. This excess is partially offset by a rather short crop of sweet potatoes estimated at 66 million bushels—6 million bushels below average.

The fruit crop is big, even on a per capita basis, and, with exports restricted, the supply available for domestic consumption will be large. Although the acreage of fruit in bearing is about the same as it was a dozen years ago the acreage devoted to the heavy-yielding orange and grapefruit crops has been expanding and these fruits form an increasing proportion of the supply. Commercial apple production this year is 5 per cent below average. Cranberries are 3 per cent below average, but the peach crop was about average. Pears are up 22 per cent and grapes 14 per cent.

(Continued on page 26)

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Swedish Phosphates From Apatite

Progress is being made in obtaining phosphate from apatite available in Sweden, and it is expected that by the Fall of 1940 a great deal more will be known about the practicability of utilizing this source of an important fertilizer ingredient. From what can be learned, it would appear that the proposed utilization of apatite in Sweden can be regarded only as a war-time measure, because it appears from results so far obtained that there is no likelihood of obtaining phosphates from apatite on a price basis that can compete with imports.

Early in the last decade, experiments had already been carried out in Sweden on the extraction of phosphate from apatite. Production was successful although virtually on a laboratory scale and in quantities much too small to reduce costs to make it possible to compete with imports. Very little of a practical nature had been accomplished up to the latter part of 1939.

At the outbreak of the present European war, the former rather leisurely experimentation became a matter of considerable importance. Action was initiated in several directions, out of which three different methods for the extraction of phosphate from apatite have been developed.

The Swedish Government is keenly interested and has subsidized experimentation to the extent of about 100,000 crowns ($25,000). The actual work was done by Stockholms Superfosfatfabricks Aktb. and the Elektrövarmeinstitut, Stockholm. Also cooperating in these experiments are the Academy of Engineering Science, the Geological Survey of Sweden, and the semi-governmental company, Luossavaara-Kiirunavaara Aktb.

Of the three methods being tested at present (none of which as yet is perfected), two are melting processes and one is a sintering process similar to that used in the treatment of iron ore. At present one of the melting methods (the so-called "stav" method) seems the most promising, although problems concerned with reducing the melting temperatures now used are still to be solved. It is stated that this method promises possibilities for treatment of imported raw phosphates for the output of a product similar to Thomas phosphate and a fertilizer superior to superphosphate.

The Alnön phosphate deposits are regarded as one of Sweden's sources of raw materials, but the Geological Survey of Sweden informs

us that owing to the severity of the past winter no investigations have been carried out since the preliminary ones by Doctor Eckermann made in the summer of 1939. However, investigations have now been started, including diamond drilling, and analysis of the chemical structure of deposits. It is probable that definite reports will be available in September or October, 1940.

We are informed that at the Malmberget deposits a small plant has been constructed to produce raw material, which it is hoped can be used eventually in producing phosphate. Hitherto this plant has furnished material to laboratories only. The phosphate is extracted from waste resulting from the magnetic concentration of iron ore. The waste is concentrated and the salts are obtained by a flotation process. —Commercial Attaché George C. Howard, Stockholm.

POUND OF NITROGEN FEEDS APPLE TREE FOR A WHOLE YEAR

A 600 pound crop of apples from a vigorous tree 25 years old removes about one-third of a pound of nitrogen from the soil. For growth of its wood, bark, and roots such a tree uses about a half pound of nitrogen. The leaves used from a half pound to a pound of nitrogen in their growth and development, but this is restored to the tree and soil, and is not ultimately removed from the orchard. So—if loss of nitrogen by leaching can be prevented—a pound of actual nitrogen a year for a tree in full bearing is an ample supply. To much nitrogen checks the desirable coloring of the fruit. About 6 pounds of nitrate of soda or 5 pounds of sulphate of ammonia would supply a pound of nitrogen.

A study of Dr. J. R. Magness of the U. S. Department of Agriculture included chemical analysis of various parts of the tree at frequent intervals during the year. Analysis showed that a thrifty well-fed tree absorbs and stores nitrogen, particularly in its roots, and releases this reserve in the weeks when new growth is occurring and leaves are expanding, and when more nitrogen is required than the tree can be expected to draw from the soil in this peak period.

It has been announced that M. H. Read & Associates, of Charleston, S. C., have acquired a controlling interest in the Southern States Phosphate & Fertilizer Co., and of its subsidiary, the Chatham Chemical Co., both of Savannah, Ga.

BAUGH PHILADELPHIA PLANT DAMAGED BY FIRE

Shortly before midnight on October 17th, the Philadelphia plant of The Baugh & Sons Company was swept by a fire of undetermined origin, destroying a number of the 56 buildings which were of frame construction. The fire spread rapidly and threatened the storage tanks of the adjoining American Distilling Co. which contained about 5,000,000 gallons of alcohol, but the favorable direction of the wind allowed the firemen to prevent their catching fire.

The company has announced that arrangements have been made to take care of all customers' requirements, pending decision on plans for future construction.

TVA NITROGEN PLANT PLANNED

It has been reported that the Tennessee Valley Authority will soon begin the construction of a nitrogen fixation plant near Muscle Shoals to produce ammonium nitrate for the War Department. The plant, which will have a daily capacity of 150 tons, will be owned by the War Department and operated by TVA. When no longer needed for defense purposes, the plant would either be closed, or would be converted to make fertilizer materials.

JAPANESE TO DEVELOP PHOSPHATE DEPOSITS IN FRENCH INDO-CHINA

Negotiations are being conducted in Japan with the view to establishing a large-scale company for development of apatite deposits in French Indo-China. Plans proposes amalgamation of existing Japanese firms now engaged in developing the nitrate resources of French Indo-China.

GOVERNMENT REOPENS CHILEAN NITRATE PLANT

The Chilean Government has empowered the Superintendent of Nitrate and Iodine to assume charge of the operations of the nitrate of soda plant known as the Rosario de Huara Oficina, which had suspended operations because of conditions in the world nitrate market. This action was taken to alleviate the economic situation in that district which had been aggravated by the unemployment of about 800 workers from that particular plant.

AMERICA'S POTASH DEFENSES ARE IN ORDER

That adequate supplies of potash, an essential plant food in the growing of all crops, are assured America's agricultural defense program, was stated on October 22nd by Dr. J. W. Turrentine, President of the American Potash Institute, Washington, D. C., in an address before the Washington, D. C., Rotary Club. In his opening remarks the speaker contrasted the years 1914 and 1939 in both of which war was declared in Europe.

When war was declared in 1914. the price of potash soared from $35 to $350 and even to $500 per ton. In 1939 when war was declared the price was $25 per ton and there it still remains—$10 lower for the same grades of potash salts than in 1914. The reason, as pointed out by Dr. Turrentine, is that during the intervening years America has developed a potash industry now capable of meeting American requirements for this essential fertilizer ingredient, whereas in 1914 the German potash mines represented the sole source of that commodity for world agriculture.

This achievement is the result of persistent effort on the part of American geologists and technologists in seeking the establishment of an American potash industry that would guarantee this country against a critical shortage of this essential commodity such as resulted from the abrupt cessation of imports experienced in 1914.

N.F.A. SOUTHERN CONVENTION

The Sixteenth Annual Southern Convention of The National Fertilizer Association will be held in Atlanta, Ga., on November 18th, 19th and 20th. The sessions will be held at the Atlanta-Biltmore Hotel. An interesting and timely program is being arranged for this meeting.

MORRISON ADDED TO UNION POTASH STAFF

Kenneth Morrison, formerly Baltimore manager for N. V. Potash Export My. and later for the French Potash Co., has joined the staff of the Union Potash & Chemical Co. Mr. Morrison will have his headquarters in the New York office of the company at 61 Broadway and will devote his sales activities to the eastern seaboard from North Carolina to Maine.

The company's plant at Carlsbad, New Mexico, is now in partial operation and has already made substantial shipments of sulphate of potash-mangnesia, the first of this material to be produced in America. The muriate section of the plant is also in operation and first shipments are expected shortly. Sulphate of potash will also be produced and by November 4th, the plant should be in full production.

COTTONSEED MEAL PRODUCTION LOWER

During the months of August and September, receipts of cottonseed totaled 723,208 tons, compared with 1,365,181 tons during these months in 1939, according to figures released by the U. S. Bureau of Census. Production of cottonseed cake and meal during the same period amounted to 191,623 tons in 1940 and 300,628 tons in 1939. Stocks on hand on September 30, 1940, came to 95,884 tons, a decrease from the 123,222 tons on hand September 30, 1939.

The Organic Nitrogen Institute, with headquarters in Atlanta, Ga., has appropriated $1,000 for studies on organic commercial fertilizers, to be carried out at the University of Wisconsin under Professor Emil Truog.

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FERTILIZER MATERIALS MARKET

NEW YORK

Little Activity in Market. Prices Remain Steady. Cargo of European Potash Reported in Transit. Fishing Season on Chesapeake Bay About Ended.

Exclusive Correspondence to "The American Fertilizer."

NEW YORK, October 22, 1940.

Since the last reporting period, there have been no notable changes or new trends to be observed in any of the primary fertilizer materials markets. Buying interest is confined solely to routine activity, but in spite of small demand, most materials remain firm at previously reported prices.

The export market remains quiet and no new inquiries have been reported by the trade.

Nitrate of Soda

$29.40 per ton in 100-lb. bags, $28.70 in 200-lb. bags, and $27.00 in bulk, f.o.b. port warehouse. Demand is seasonal and ample port stocks are on hand.

Sulphate of Ammonia

Continues to be very tight and in heavy demand. Domestic price unchanged at $28.00 in bulk, usual Atlantic and Gulf Ports.

Superphosphate

Ordinary superphosphate is strong and this market shows no change. Triple superphosphate continues to be very tight, with demand exceeding supplies.

Potash

This market remains very firm at scheduled price. A cargo of German potash, consisting of 10,000 tons of 60 per cent muriate in bulk, is reported to be in transit and due here some time during the first week of November. This material is being offered to manufacturers at schedule.

Dried Blood

No change. Buying interest at a minimum with local production being quoted from $2.40 to $2.50 ($2.91½ to $3.04 per unit N), South American material can be bought at $2.50 to $2.60 ($3.04 to $3.16 per unit N).

Tankage

Rules easy at previously reported levels. Demand is nominal and supplies are adequate.

Nitrogenous Material

Price continues to be strictly nominal with a very dull market.

Bone Meal

Very little domestic is on the market, but South American 4½ and 50 per cent grade can be bought at from $31.00 to $32.00, c.i.f.

Fish Scrap

The fishing on Chesapeake Bay continues to be poor and some operators are ready to cease operations for the season. No new bookings of scrap have been reported. Menhaden meal is strictly nominal at $47.00 per ton, Baltimore basis.

Soya Bean Meal

The early demand has been surprisingly active and has run this market up to $29.60 per ton in bulk, delivered Boston area, or $29.20 delivered New York rate points.

BALTIMORE

Fall Shipping Season Below Expectations. Materials Market Remains Stationary. Shipments of Spanish Potash Arriving.

Exclusive Correspondence to "The American Fertilizer."

BALTIMORE, October 22, 1940.

The fall shipping season, which is now on, not only got off to a late start but from present indications it would appear the tonnage is likely to be less than anticipated, in consequence of this, there is no buying interest being manifested in further supplies of raw materials, as practically all manufacturers will be carrying over stocks until the spring season. The market on materials, however, remains stationary without any outstanding price changes.

Ammoniates.—There is practically no demand for fertilizer purposes, and the market for feeding continues about unchanged at $2.80 to $2.90 per unit of nitrogen for tankage, and $3.02 per unit of nitrogen for South American

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the number of pounds of raw material for a desired per cent. of plant food in a ton of mixed goods—or find what per cent. of a certain plant food in a ton of fertilizer produced by a specific quantity of raw materials.

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blood, but without any offerings pressing on the market to depress it.

Nitrogenous Material.—The demand is practically at a standstill and ranges from $2.55 to $2.65 per unit of nitrogen, f.o.b. Baltimore.

Sulphate of Ammonia.—This material continues scarce and while there has not been any actual shortage for domestic consumption, as many of the buyers are storing up supplies against their spring requirements, there is no doubt that a shortage will develop by the spring months unless additional supplies are released for domestic use. The export market continues firm at about $39.00 to $40.00 per ton, in bags, f.a.s. Baltimore.

Nitrate of Soda.—As is usual at this time of the year, the demand continues light and there is no question that some of the manufacturers will use nitrate in their formulas during the spring season if sulphate of ammonia continues scarce and unobtainable. Domestic producers as well as importers continue to quote $29.40 per ton of 2,000 lb., in 100-lb. bags, ex port warehouse, with differential of 70 cents per ton for 200-lb. bags and $2.40 per ton in bulk.

Fish Scrap.—Although the price of menhaden fish scrap is out of line with other feeding materials, the market remains firm at previously quoted levels of $3.75½ per unit of nitrogen and 10 cents per unit of B.P.L., f.o.b. fish factories, and as the season will soon be drawing to a close, it looks as though present market will be maintained. As far as it can be learned there is very little interest being shown in further supplies at present asking prices.

Superphosphate. — The market continues firm and unchanged at $8.00 per ton of 2,000 lb., basis 16 per cent for run-of-pile, and $8.50 for flat 16 per cent grade, both in bulk, f.o.b. producer's works, Baltimore.

Bone Meal.—No change in the market. 3 and 50 per cent domestic steamed bone meal still continues to be quoted at $32.00 to $34.00 per ton, f.o.b. Baltimore, while South American 4½ and 47 per cent raw bone ranges from $31.00 to $32.00 per ton, c.i.f. Baltimore.

Potash.—The market continues unchanged, and the arrival of several cargoes of Spanish potash during the past two weeks has encouraged fertilizer manufacturers in the belief that with further arrivals of the Spanish product and stepping up in production of domestic, there will be ample stocks to see them through for the coming spring season's business without any increase in price.

Bags.—The burlap market is ruling slightly easier since last report, and the present market is about $112.75 per thousand, basis 40 cut 54 in., for plain, 10-oz., for spring delivery at Baltimore.

ATLANTA

Cottonseed Meal Firmer Due to Late Season but Price Decline Expected Later. Spanish Potash now on the Market.

Exclusive Correspondence to "The American Fertilizer."

ATLANTA, October 21, 1940.

Contrary to expectations, cottonseed meal has been considerably firmer during the last week or ten days. Due to a late season, ginnings are behind last year and the seed movement from the gin to mills is much less than should be the case at this particular time. The pressure of seed movement, if it comes, should be around the middle of November and prices on cottonseed meal may work lower than at present, although spot meal is bringing a premium of $2.00 to $3.00 per ton over futures, which indicates that on hand stocks are negligible. Imported meal is not available for shipment south but has already supplied a large portion of the eastern trade. With a good peanut crop and an increased soya bean crop, the price on cottonseed meal looks relatively high at the present time.

Manufacturers' Sales Agents for **DOMESTIC**

Sulphate of Ammonia

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Potash is in better supply due to several cargoes of Spanish material which are now offered on the market. Increased production on the part of domestic manufacturers likewise has taken the edge off this market.

The new schedule of prices of nitrate has been issued, namely $27.00 in bulk, f.o.b. the port, with 200-lb. bags at $28.70 and 100-lb. bags at $29.40. Ample supplies seem to be either on hand or en route.

The market on materials is more or less unchanged and prices generally are as follows:

Tankage.—South American, $2.60 ($3.16 per unit N) and 10 cents, c.i.f.

Blood.—South American, $2.55 ($3.10 per unit N), c.i.f.

Sulphate of Ammonia.—Unchanged but supplies limited.

Nitrate of Soda.—As reported above.

Cottonseed Meal.—Prime 8 per cent, $25.00 to $25.50, basis Memphis, or $1.50 per ton higher, southeastern mill points.

Steamed Bone Meal.—3 and 50 per cent, $31.50, ex-vessel.

Raw Bone Meal.—4½ and 45 per cent, $31.50, ex-vessel.

WILMINGTON

Fish Meal Production Disappointing with No Surplus Expected. Farmers Holding Cottonseed Meal for Direct Sale Later in Season.

Exclusive Correspondence to "The American Fertilizer."

WILMINGTON, October 21, 1940.

Markets continue very quiet with little thought of buying. The extremely disappointing catch of menhaden along the southern coast has put all the fish factories behind in their deliveries, and is putting a definite stop to any further offerings for delivery, as made. While it is believed that present contracts will be filled by January 1st, it is not believed that there will be the usual surplus to be offered later in the season.

Cottonseed continues to be a headache to the buyers. The crushers report that the farmers are demanding the meal from their seed and hauling it home and the mills find it very difficult to accumulate any meal that will be free for direct sale. The peculiar thing about this situation is that we will have the largest tonnage of seed for crushing in years and the demand should be nothing above normal; consequently there is no reason to expect anything but a low price for the meal. However, the farmers will bring their meal back on the market after the first of the year and demand a bonus price from the fertilizer manufacturer for this meal, either in payment of accounts or on the purchase of fertilizer for next season. Prime 7 per cent meal has been bought around $25.00 at the South Carolina mills, but all sales have been in very small volume.

There is no interest in organics such as blood, nitrogenous material, soya bean meal, etc.

CHICAGO

Increased Price of Vegetable Meals Keep Animal Organics at High Levels. Feed Market Unsettled.

Exclusive Correspondence to "The American Fertilizer."

CHICAGO, October 21, 1940.

But little activity has occurred in the organic market during the past two weeks. Improvement in prices for cottonseed meal and soya bean meal has encouraged organic producers to continue in their expressed belief of a higher market during the fall and winter. They admit that such advance will depend largely on the southern season.

The feed market has been rather chaotic. A week after digester tankage was reduced

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$2.50 per ton, the list price was again raised the same amount.

Nominal prices are as follows:

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PHILADELPHIA

Greater Interest in Materials, Particularly in Organics. Sulphate of Ammonia Still Scarce.

Exclusive Correspondence to "The American Fertilizer."

PHILADELPHIA, October 22, 1940.

The past week has shown more interest in fertilizer materials. Organics came in for the larger share of attention. Sulphate of ammonia remains tight.

Nitrate of Soda.—Shipments very light. Price remains $27.00 in bulk; $28.70 in 200-lb. bags and $29.40 in 100-lb. bags, in carload lots.

Sulphate of Ammonia.—Firm. Shipments on contracts being made as scheduled. Export demand continues.

Dried Blood.—Firm. Offered at $2.40 to $2.50 ($2.91½ to $3.04 per unit N). South American at $2.50 ($3.04 per unit N).

Tankage.—Firm. Demand fair. Price $2.50 ($3.04 per unit N) and 10 cents f.o.b. South American, $2.60 to $2.65 ($3.16 to $3.22 per unit N) and 10 cents c.i.f.

Bone Meal.—Steady. 1 and 65 per cent at $36.00 to $37.00; 3 and 50 per cent at $33.00 to $34.00; 4½ and 45 per cent (South American) $31.00 to $31.50.

Superphosphate.—Price unchanged.

Potash.—Published schedule prevails.

TENNESSEE PHOSPHATE

New Phosphorus Plants nearing Completion. Dry Weather Still Hinders Mining Operations. Shipments Continue in Record Volume.

Exclusive Correspondence to "The American Fertilizer."

COLUMBIA, TENN., October 21, 1940.

Work continues to progress satisfactorily on the huge new electric phosphorus furnaces under construction at Columbia and Mt. Pleasant, and it is estimated that about two months more work will bring them to blast.

Progress of the enormous anodes on trucks through the streets of Columbia and Mt. Pleasant, en route from the National Carbon Plant to the furnace sites, reminds one of the loads of enormous saw legs that used to be such a common sight in this area of hardwood timber, rapidly becoming so scarce.

A few more rains have been enjoyed, but still far from sufficient to relieve the situation, and great holes are noticeable in the stock piles of washed storage at all the plants in this field.

Shipments of phosphate rock both crude and ground continue to go out at a rapid rate, and it looks now as if October will show as great an increase over 1939 as did September. Shipments have been especially active of ground rock for use by large stock farms for topdressing their pastures, some of the large orders for this purpose having been placed by commercial fertilizer manufacturers themselves for some of their large customers. Applications of sulphate of ammonia and in some areas muriate of potash will be made by some of these large stock farms to their grass pastures later this winter or early spring.

The author of these reports has had his attention called to an error made by him in the report of September 22nd, which appeared in THE AMERICAN FERTILIZER of September 28, 1940, in stating that "some experiments of the Potash Institute report results from such mix-

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tures better than with superphosphate." Of course, the Potash Institute does not make experiments, nor does it report on same itself. The experiments particularly referred to were really made by certain members of the staff of one of the Agricultural Colleges, and no report at all has as yet been officially made on same. One of the staff of the Potash Institute called the attention of the writer and certain members of his staff to pictures and statements of comparative yields from the experiments in progress, from which any one was able to observe the comparison alluded to, but no such comparison or statement was made by the Potash Institute, and the writer should not have permitted them to be officially given as responsible.

His mistake was a most natural, even though unexcusable one, as he had been making this same claim for a great many years, based on the work of many experiment stations, including Wisconsin and Mississippi among others, where mixtures of muriate or sulphate of potash, nitrate of soda or sulphate of ammonia, and respectively finely ground phosphate rock and superphosphate, were compared, and in most cases where muriate of potash and sulphate of ammonia were used, the rock phosphate gave better results than superphosphate, on unlimed plots. His natural exhuberance at the fact of some of the Potash Institute staff having seen the preliminary results named independently, and having themselves brought them to his attention, led to his unjustified official connection of the Institute therewith, for which he sincerely apologises.

NEW AND OLD METHODS OF PROCESSING PHOSPHATE

(Continued from page 10)

Although the Tennessee Valley Authority, the only producer, has made and distributed several thousand tons of calcium metaphosphate, principally to State agricultural experiment stations for use in plant-growth tests, it is too early to venture an opinion on the probable future status of the material as a commercial fertilizer. The cost of making elemental phosphorus will be a very important factor, if not the decisive one.

Raw Phosphate Rock

Direct use of ground raw phosphate rock as a source of phosphorus for plant growth was recommended and practiced in this country as early as 1870.[31] Including both ground rock and natural finely divided phosphate, such as the so-called soft phosphate of Florida, the domestic consumption of mineral phosphate for direct application to the soil amounted to 95,667 long tons in 1939, as compared with 2,192,779 tons used in the manufacture of superphosphates. Probably two-thirds of the mineral phosphate used for direct application comes from the Tennessee brown-rock deposits, and nearly all the remainder originates in Florida. Approximately 50 per cent of the entire consumption is used in Illinois.

Although the crop-producing value of raw mineral phosphate, in comparison with that of the more soluble, chemically processed phosphate, has been the subject of much study and discussion, there is still a wide difference of opinion on the relative merits of the two types of materials. In those cases where good results have been obtained with raw phosphate, it has usually been applied in liberal quantities to legumes or other green manure crops in rotation systems on non-alkaline soils. It has been demonstrated beyond question that raw mineral phosphate is a poor source of phosphorus for crops on alkaline soils, such as those in western United States.[32]

Other Phosphates

Potassium metaphosphate is of interest as a prospective fertilizer material because of its high content of plant food. The pure salt contains 39.9 per cent of K_2O and 60.1 per cent of P_2O_5. The product obtained by reaction of potassium chloride with phosphoric acid at 700° C. or higher temperature is only slightly soluble in water, but it is readily soluble in neutral ammonium citrate solution, and it appears to be a good source of potassium and phosphorus for plants.[33] Potassium metaphos-

[31] Waggaman, W. H., Wagner, C. R., and Gardiner, R. F., U. S. Dept. Agr., Bull. No. 699, 119 pp. (1918).

[32] See footnote 28, references 2 to 5.

[33] Madorsky, S. L., and Clark, K. G., Ind. Eng. Chem. 32, 244-8 (1940); Bartholomew, R. P., and Jacob, K. D., J. Assoc. Official Agr. Chem. 16, 598-611 (1933).

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See Page 4

phate has been produced only on an experimental scale. Field tests with the material are now being made by several State experiment stations.

It has been shown that simultaneous volatilization of phosphorus and potassium can be effected by smelting a mixture of coke, phosphate rock and potash silicate, such as Georgia shale or wyomingite in a reducing atmosphere.[34] Although the process deserves consideration because it offers a means for the utilization of our large deposits of potash silicates and because the products can be converted to concentrated fertilizers that contain both potassium and phosphorus in an easily transportable form, further work must be done before final conclusions as to its practicability can be drawn.

Numerous processes have been proposed for the manufacture of citrate-soluble phosphate by heating phosphate rock with alkali salts, usually the carbonates or sulphates of sodium. As yet, attempts to operate such processes on a commercial scale have not met with sustained success in this country, though some material has been produced and marketed in a small way at various times. In Germany, however, a product known as Rhenania phosphate has been manufactured on a large scale for some years by heating phosphate rock with alkali salts under certain conditions.[35] The production of Rhenania phosphate is said to be about 100,000 tons annually.

The products of these processes are alkaline in reaction and show a wide range of citrate-soluble phosphorus. Several samples analyzed in the writer's laboratory contained 25.7 to 30.4 per cent of total P_2O_5, of which 57 to 92 per cent was soluble in neutral ammonium citrate solution. In some cases, conversion of the phosphorus into the citrate-soluble condition is accompanied by the volatilization of a considerable portion of the fluorine in the phosphate rock, while in others evolution of the fluorine is small. To the extent that the phosphorus is converted into the citrate-soluble condition these materials appear to be excellent sources of phosphorus for plants on non-alkaline soils.

In conclusion, mention should be made of the role of bone products in the fertilizer industry. Crushed bone was used directly as a soil amendment for many years prior to 1840, when Liebig proposed that it be treated with sulphuric acid to increase the fertilizing value of the phosphorus. In the initial years of the chemical fertilizer industry bone was the only phosphatic material available for the manufacture of superphosphate, and it continued to be widely used for this purpose until after the middle of the nineteenth century. With the discovery of large deposits of mineral phosphate, however, and the gaining of experience in the manufacture of superphosphate from this cheaper raw material, the chemical processing of bone for fertilizer gradually waned until today only a negligible quantity of superphosphate is made from bone. For example, in 1937 the entire domestic production of superphosphate from bone amounted to only 8,000 short tons, made from spent bone black.[36] On the other hand, a considerable quantity of raw bone meal and steamed bone meal, 85,000 short tons in 1937, is still used as fertilizer in this country, both for direct application as such to the soil, principally for lawns and gardens, and as an ingredient of mixed fertilizers for general crops. Also, considerable bone phosphate finds its way into mixed fertilizers in the form of tankage, fish scrap and acidulated fish.

Since this country possesses the largest deposits of phosphate rock in the world, the supply of raw material presents no serious problem. There are, however, the vitally important problems of (1) decreasing the cost of phosphate fertilizer to the farmer, (2) increasing the efficiency of the plant utilization of phosphate applied to the soil, and (3) obtaining better utilization of the native phosphorus of the soil, all of which are inseparably associated with the problems of soil conservation and low-cost production of crops.

[34] Ross, W. H., Mehring, A. L., and Jones, R. M., Ind. Eng. Chem. **16**, 563-6 (1924); Pike, R. D., *ibid.* **22**, 344-54 (1930); Royster, P. H., and others, U. S. Dept. Agr., Tech. Bull. No. **543**, 75 pp. (1937).

[35] Messerschmitt, A., Ztschr. angew. Chem. **35**, 537-43 (1922); Angew. Chem. **51**, 197-203 (1938).

[36] Mehring, A. L., Year Book Com. Fertilizer **1939**, 32-41.

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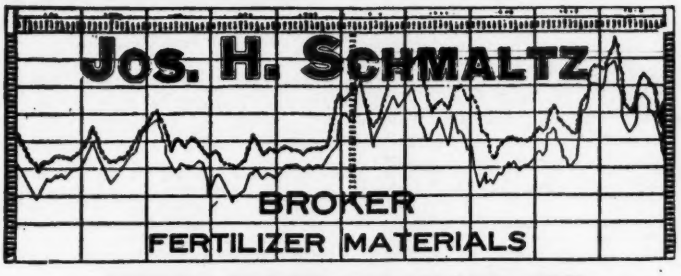

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OCTOBER CROP REPORT

(Continued from page 11)

Citrus production continues to expand and the crop from the 1940 bloom, to be picked during about a 12-month period beginning this fall, may be the largest on record.

Supplies of fresh vegetables for shipment, including such tender crops as green beans and tomatoes, are still available in some northern areas. The hardier kinds will continue to move from fields to market in volume for some weeks and potatoes, sweetpotatoes, cabbage, carrots, onions, and celery are moving into storage. But the 1940-41 season is starting in the South and Far West and new crop supplies will gradually increase in importance.

A preliminary survey of movements during the 1940 season as a whole shows that production of 26 vegetable crops for shipment, excluding potatoes and sweet potatoes but including supplies of other vegetables still to be harvested for fresh consumption or for storage, will be about 4 per cent larger than in 1939 and 17 per cent above average.

The combined acreage of 10 vegetable crops planted or intended to be planted for fall and winter harvest is indicated to be almost 5 per cent larger than last year, and about 25 per cent above the 10-year average.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

of THE AMERICAN FERTILIZER, published bi-weekly at Philadelphia, Pa., for October 1, 1940.

STATE OF PENNSYLVANIA } ss.
COUNTY OF PHILADELPHIA }

Before me, a Notary Public, in and for the State and county aforesaid, personally appeared A. A. Ware, who, having been duly sworn according to law, deposes and says that he is the editor of THE AMERICAN FERTILIZER, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business manager are:

Name of	Post-office Address
Publisher, Ware Bros. Company,	1330 Vine St., Philadelphia, Pa.
Editor, A. A. Ware,	1330 Vine St., Philadelphia, Pa.
Managing Editor, None.	
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2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

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3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is (This information is required from daily publications only.)

A. A. WARE, Editor.

Sworn to and subscribed before me this 16th day of October, 1940.

A. F. WALSH,
Notary Public.

(My commission expires March 5, 1941.)

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Sackett & Sons Co., The A. J., Baltimore, Md.

BELTING—Chain
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

BELTING—Leather, Rubber, Canvas
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

BOILERS—Steam
Atlanta Utility Works, East Point, Ga.

BONE BLACK
American Agricultural Chemical Co., New York City.
Armour Fertilizer Work, Atlanta, Ga.
Huber & Company, New York City.

BONE PRODUCTS
American Agricultural Chemical Co., New York City.
Armour Fertilizer Work, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

BORAX AND BORIC ACID
American Potash and Chem. Corp., New York City.
Pacific Coast Borax Co., New York City.

BROKERS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Keim, Samuel L., Philadelphia, Pa.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

BUCKETS—Elevator
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

HENRY L. TAYLOR, *Broker*
Bentley's Code Cable Address "HLTAYLOR"
NORTH CAROLINA BANK BLDG., WILMINGTON, N. C.
Menhaden Fish Products and Fertilizer Materials

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BUCKETS—For Hoists, Cranes, etc., Clam Shell, Orange Peel, Drag line, Special; Electrically Operated and Multi Power
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.

BURNERS—Sulphur
Chemical Construction Corp., New York City.

BURNERS—Oil
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CABLEWAYS
Hayward Company, The, New York City.

CALCIUM-NITRATE
Synthetic Nitrogen Products Co., New York City.

CAL-NITRO
Synthetic Nitrogen Products Co., New York City.

CARBONATE OF AMMONIA
American Agricultural Chemical Co., New York City.
Du Pont de Nemours & Co., E. I., Wilmington, Del.

CARS—For Moving Materials
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CARTS—Fertilizer, Standard and Roller Bearing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

CASTINGS—Acid Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

CASTINGS—Iron and Steel
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CEMENT—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

CHAIN DRIVES—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAINS AND SPROCKETS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAMBERS—Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CHEMICAL APPARATUS
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

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Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
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Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHEMISTS AND ASSAYERS
Gascoyne & Co., Baltimore, Md.
Shuey & Company, Inc., Savannah, Ga.
Stillwell & Gladding, New York City.
Wiley & Company, Baltimore, Md.

CLUTCHES
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CONCENTRATORS—Sulphuric Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CONDITIONERS AND FILLERS
American Limestone Co., Knoxville, Tenn.

CONTACT ACID PLANTS
Chemical Construction Corp., New York City.

COPPER SULPHATE
Tennessee Corporation, Atlanta, Ga.

COTTONSEED PRODUCTS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

CRANES AND DERRICKS
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill. and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CYANAMID
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

DENS—Superphosphate
Chemical Construction Corp., New York City.
Stedman's Foundry and Mach. Works, Aurora, Ind.

Andrew M. Fairlie
CHEMICAL ENGINEER
22 Marietta Street Building ATLANTA, GA.
CABLE ADDRESS: "SULFACID ATLANTA"

SULPHURIC Acid Plants . . . Design, Construction, Equipment . . . Operation . . . Mills-Packard Water-Cooled Acid Chambers, Gaillard Acid-Cooled Chambers, Gaillard Acid Dispersers, Contact Process Sulphuric Acid Plants.

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DRYERS—Direct Heat
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

DRIVES—Electric
Link-Belt Company, Philadelphia, Chicago.

DUMP CARS
Link-Belt Company, Philadelphia, Chicago.
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Stedman's Foundry and Mach. Works, Aurora, Ind.

DUST COLLECTING SYSTEMS
Sackett & Sons Co., The A. J., Baltimore, Md.

ELECTRIC MOTORS AND APPLIANCES
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

ELEVATORS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ELEVATORS AND CONVEYORS—Portable
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

ENGINEERS—Chemical and Industrial
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ENGINES—Steam
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Sackett & Sons Co., The A. J., Baltimore, Md.

EXCAVATORS AND DREDGES—Drag Line and Cableway
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill. and Cedar Rapids, Iowa.

FERTILIZER MANUFACTURERS
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Farmers Fertilizer Co., Columbus, Ohio.
International Agricultural Corp., New York City.
Smith-Rowland Co., Norfolk, Va.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

FISH SCRAP AND OIL
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

FOUNDERS AND MACHINISTS
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GARBAGE TANKAGE
Wellmann, William E., Baltimore, Md.

GEARS—Machine Moulded and Cut
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GEARS—Silent
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Sackett & Sons Co., The A. J., Baltimore, Md.

GELATINE AND GLUE
American Agricultural Chemical Co., New York City.

GUANO
Baker & Bro., H. J., New York City.

HOISTS—Electric, Floor and Cage Operated, Portable
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.

HOPPERS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

IMPORTERS, EXPORTERS
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

IRON SULPHATE
Tennessee Corporation, Atlanta, Ga.

INSECTICIDES
American Agricultural Chemical Co., New York City.

LACING—Belt
Sackett & Sons Co., The A. J., Baltimore, Md.

LIMESTONE
American Agricultural Chemical Co., New York City.
American Limestone Co., Knoxville, Tenn.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

LOADERS—Car and Wagon, for Fertilizers
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Acid Making
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Coal and Ash Handling
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Elevating and Conveying
Atlanta Utility Works, East Point, Ga.
Hayward Company, The, New York City.
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MACHINERY—Power Transmission
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Pumping
Atlanta Utility Works, East Point, Ga.

MACHINERY—Tankage and Fish Scrap
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
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MAGNESIA
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Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MANGANESE SULPHATE AND CARBONATE
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MANGANESE SULPHATE
Tennessee Corportion, Atlanta, Ga.

MIXERS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

NITRATE OF SODA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
Chilean Nitrate Sales Corp., New York City.
Huber & Company, New York City.
International Agricultural Corp., New York City.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

NITRATE OVENS AND APPARATUS
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NITROGENOUS ORGANIC MATERIAL
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Du Pont de Nemours & Co., E. I., Wilmington, Del.
Huber & Company, New York City.
International Agricultural Corp., New York City.
Smith-Rowland Co., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

NOZZLES—Spray
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PACKING—For Acid Towers
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
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Ruhm, H. D., Mount Pleasant, Tenn.
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Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

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PIPES—Wooden
Stedman's Foundry and Mach. Works, Aurora, Ind.

PLANT CONSTRUCTION—Fertilizer and Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
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POTASH SALTS—Dealers and Brokers
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Agricultural Corp., New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Synthetic Nitrogen Products Co., New York City.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

POTASH SALTS—Manufacturers and Importers
American Potash and Chem. Corp., New York City.
Potash Co. of America, Baltimore, Md.
United States Potash Co., New York City.

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Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

PUMPS—Acid-Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
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PYRITES—Brokers
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Baker & Bro., H. J., New York City.
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SCRAPERS—Drag
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SEPARATORS—Including Vibrating
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Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
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International Agricultural Corp., New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

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American Agricultural Chemical Co., New York City

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Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

TANKAGE—Garbage
Huber & Company, New York City.

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TILE—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

TOWERS—Acid and Absorption
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

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Jeffrey Manufacturing Co., The, Columbus, Ohio.
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UREA-AMMONIA LIQUOR
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SAMUEL D. KEIM

By-Products *and* Fertilizer Materials

(SINCE 1898)

1612 MARKET STREET
PHILADELPHIA, PENNA.

E. DOUGHERTY, JR., Manager

MONARCH
Chamber Sprays

Have replaced other sprays in most plants throughout the world. Made of stoneware. Will not break or crack from temperature changes. Hard lead body and cap.

For Scrubbing Acid Gases

Where acids affect our cast brass or "Everdur" nozzles, Fig. 645, we suggest **Hard Rubber Nozzles.**

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Fig. 6020 **MONARCH MFG. WORKS, INC.**
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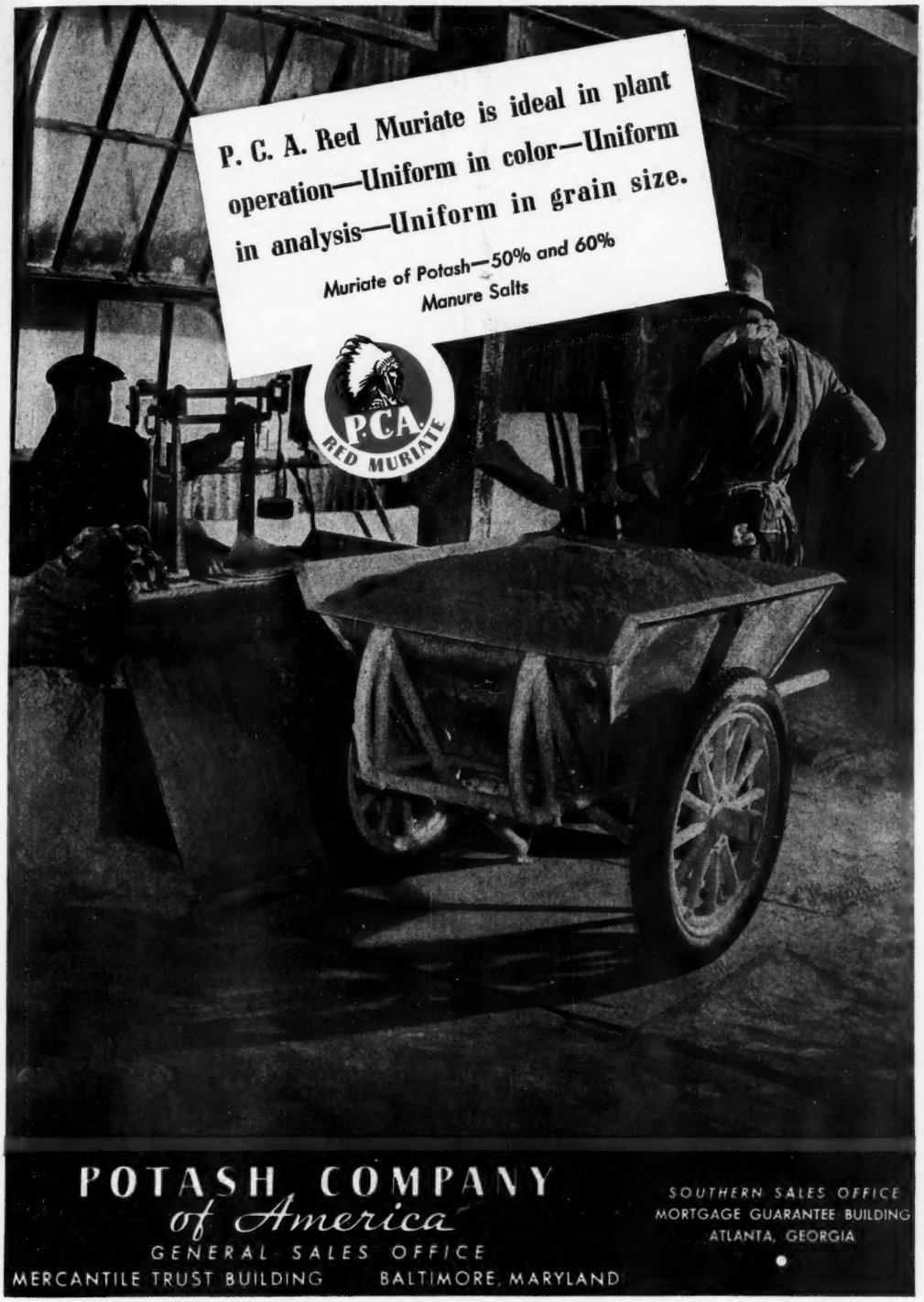
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